

A Time Differential Perturbed Angular Correlation Study of Proton Irradiated Cadmium

| | |
|------------------------------|---|
| 著者 | Hanada R. |
| journal or publication title | CYRIC annual report |
| volume | 1983 |
| page range | 64-66 |
| year | 1983 |
| URL | http://hdl.handle.net/10097/49167 |

I. 16 A Time Differential Perturbed Angular Correlation Study of
Proton Irradiated Cadmium

Hanada R.

Research Institute for Iron, Steel and Other metals, Tohoku University

For the purpose to apply the time differential perturbed angular correlation method (PAC) to the problems of material science such as lattice defects or impurities in metals, a PAC system has been constructed and tested, of which result will be briefly reported.

Since the purpose of the present experiment is to test whether the present PAC system is properly operating or not, a measurement was performed on $^{111}\text{In}(^{111}\text{Cd})$ nuclei in cadmium, of which a γ cascade (γ_1 :171 keV, γ_2 :245 keV) has been known to be the most suitable for PAC studies.^{1,2,3)} Since detailed studies of ^{111}In in Cd have already been performed by Wutthum et al.⁴⁾ and by others^{1,3)}, the comparison of the present with their's will be useful to test and to adjust our PAC equipment.

A cadmium foil (99.9 %) of 0.05 mm thickness was attached to a liquid nitrogen cryostat placed at the 31st course of AVF cyclotron. The specimen was irradiated by 25 MeV proton (0.2 $\mu\text{A} \times 8$ hrs) at 77 K. Although both radiation damage and $^{111}\text{In}[(p,n), (p,2n)]$ are produced by the irradiation, the former was intentionally annealed out by warming up the specimen to the room temperature. This is to avoid the complexity of the damage effect on the PAC spectrum.

The irradiated cadmium specimen, in which now ^{111}In is present, was placed between two NaI-photomultiplier detectors, one of which signal is analysed to detect only the first γ -ray(γ_1) and gives the start signal and another for γ_2 to give the stop signal. The number of the cascade event was accumulated in a MCA as a function of the time duration between γ_1 and γ_2 (0-500 nsec) with using a TAC. Such a measurement was performed with the angle between two detectors for 180 deg.(N(180)) and also for 90 deg.(N(90)).

Figure 1 shows a result of such a measurement, where the logarithm of N(90) and N(180) are plotted against the time duration. (The upper two curves.) Also the value of $(N(180)-N(90))/(N(180)+N(90)) \equiv \eta$ are plotted in the lower part of the figure.

For the TDPAC measurement, the count rate $N(\theta, t)$ is given²⁾ by eq. (1).

$$N(\theta, t) = N_0 \exp(\lambda t) W(\theta, t) \quad (1)$$

where λ is the decay constant of the intermediate state for the γ cascade and $W(\theta, t)$ is the TDPAC function. The $t_{1/2}$ of the intermediate state was determined to be 86 ± 2 nsec which shows a good agreement with the tabulated value (84 nsec). For the case of polycrystalline specimen as used in the present, $W(\theta, t)$ is given²⁾ by eq. (2)

$$W(\theta, t) = \sum_{\lambda=\text{even}} G_{\lambda\lambda}(t) \cdot A_{\lambda\lambda} \cdot P_{\lambda}(\cos\theta) \quad (2)$$

where $A_{\lambda\lambda}$ is the directional correlation coefficient, P_{λ} is Legendre function and $G_{\lambda\lambda}$ is the differential attenuation coefficient, which contains all the informations about the interaction of the $^{111}\text{In}(^{111}\text{Cd})$ nuclei with the surrounding atoms in the h.c.p. cadmium lattice. For the case of $^{111}\text{In}(^{111}\text{Cd})$ with $I = 5/2$, eq. (2) is simplified and the ratio η approximately gives the important term of $3/4 \cdot A_{22} \cdot G_{22}(t)$, where A_{22} depends only on the nuclear properties.

The obtained $G_{22}(t)$ shows a periodic oscillation with the period of 54 nsec, of which magnitude shows an excellent agreement with those obtained by others.³⁾ The oscillation reveals that the $^{111}\text{In}(^{111}\text{Cd})$ nuclei precess under the influence of the electric field gradient (E.F.G.) of cadmium lattice. No attenuation is present in the observed $G_{22}(t)$. This shows that the E.F.G. has no distribution revealing that all the $^{111}\text{In}(^{111}\text{Cd})$ nuclei stay at a unique lattice site, namely, in a substitutional position. This is reasonable, since the radiation damage introduced by irradiation has been known to anneal out below the room temperature in the case of cadmium.

Although the present results show that the PAC method is possible in the present set up, further improvements are necessary to apply it to practical problems as *in situ* radiation damage studies. For instance the ratio of the dip in the N curves to the total count $N(90)$ or $N(180)$ in the present are smaller than the observed by others^{1,3,4)} and hence can be improved. Also the reduction of the back-ground γ -rays, which are emitted by the nuclei other than $^{111}\text{In}(^{111}\text{Cd})$ which are inevitably produced by the proton irradiation, will be necessary to perform the PAC experiment in a reasonably short time.

Acknowledgement

The author is indebted to Prof. M. Fujioka for his encouragement to initiate the work. Also he is indebted to Prof. H. Orihara for his suggestions in the selection of the detectors used in the present. Also he is deeply indebted to Dr. K. Ishii for his performing the cryostat alignment. Also he deeply thanks to the staff of CYRIC for the operation of the cyclotron and the beam transport.

References

- 1) Raghavan P. and Raghavan R. S., Phys. Rev. Lett. 27, (1971) 724.
- 2) Behar M. and Steffan M., Phys. Rev. C 7, (1973) 788.
- 3) Hyperfine interaction in Radioactive Nuclei, Ed. by J. Christiansen, published by Springer Verlag (1983).
- 4) Wutthum W., Weidinger A., Sander W., Metzner H., Klinger W. and Böhm R., Zeit. Physik B 33, (1979) 155.

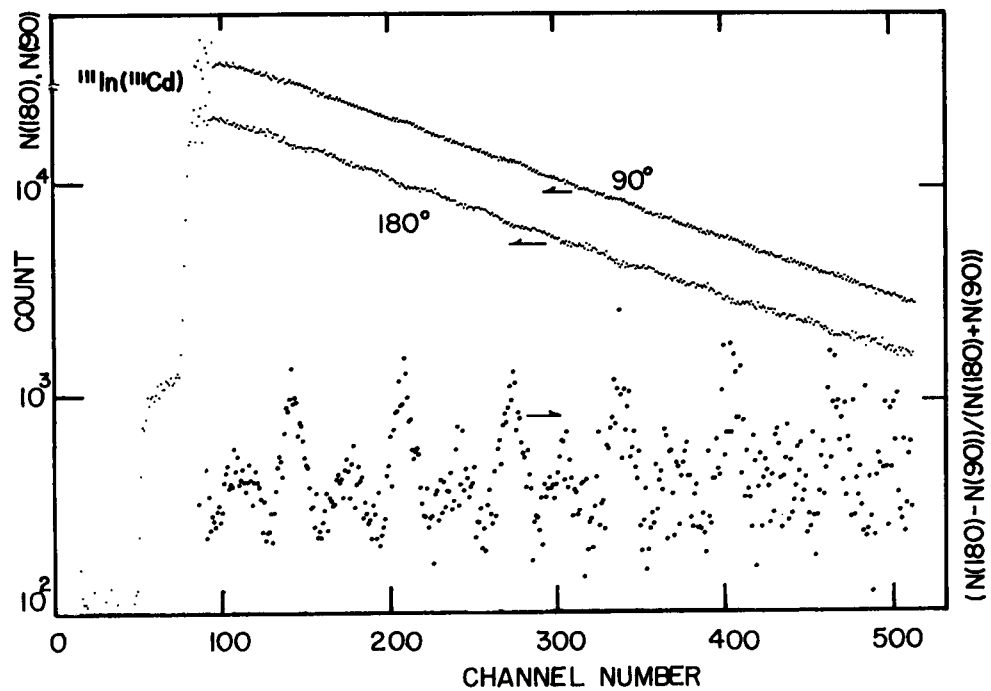


Fig. 1. A TDPAC spectrum in proton irradiated cadmium (R.T. Measurement).